RATING OF FIBERS IN STEEL FIBER REINFORCED CONCRETE

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ABSTRACT

Evaluation of dispersion fibers in steel fiber reinforced concrete (SFRC) is of great importance. Especially for production and processing of fiber-processing steps. The article is a comparison of current evaluation methods and developed an alternative proposal evaluation. Each figure for dispersion fiber has advantages but also its importance for practical usefulness. These data from different studies representing the fiber to a specific unit. For example, volume or area. Currently, the research focuses on equitable deployment of fibers of different successive steps of production. Before it is necessary to choose the most appropriate method of assessing or assemble a new one. The paper describes a new method for the evaluation of usable practice directly on site.

Key words: *steel fiber reinforced concrete, dispersion, evaluation*

1 INTRODUCTION

The desired properties of fiber reinforced structures determined by the designer. Chassis design designer will meet these requirements, but only if they will meet throughout its substance. The contractor must ensure that the production of homogeneous structure, i.e. the structure with evenly distributed fibers. Control of uniformity of distribution of fibers, which establish the structure achieving the desired properties is therefore desirable. Checking may take place at any step in the manufacture of fiber reinforced structures. The figure should represent the distribution of the fibers and the confirmation of the production process and fiber-incorporation into the structure.

2 EVALUATION METHODS OF DISPERED FIBERS

In the process of manufacturing fiber reinforced concrete structures can be assessed homogeneity during production of the fresh mixture or hardened. It is also possible to distinguish destructive or non-destructive method. That's up from structural damage or samples. The method of obtaining samples and the measurement depends on the indication of homogeneity fibers.

2.1 Non-destructive methods

The most common non-destructive testing methods include checking the amount of fibers added to the concrete. Control is performed during the concreting of fresh fiber concrete. Fiber-sample is diluted to a consistency until the point where it is possible to separate the fibers powerful magnet. After weighing them and converting the unit of measurement ($kg.m^{-3}$) to receive data about the concentration, which is then compared to the desired state. Deviation assuming homogeneous material is permitted to 10% by weight of fibers. [6,12] A significant simplification of control allows the device dosometer, which also uses the principle of the magnet. [9] Basic design dosometer hopper is equipped with a strong permanent magnet. SFRC mixture of a given volume is poured into the hopper, the fibers are collected at the contact with the magnet, while the rest of the mixture goes into the container arranged under the dosometer. After lifting magnet fibers lapse into the prepared container and after cleaning and drying weighed. As the sample volume is known and the weight of the fibers separated from the sample using the mathematical relationship can be obtained the value of dosing fibers in the sample.

Another way of measuring the magnetic induction test. The principle of the test is to indirectly determine the concentration of fibers in the sample magnetic induction. When measuring the comparative determines the concentration of fibers in the hardened SFRC. The method is applicable only to steel filaments. Utilizing that method, it shall be given to such. [7,2] It is used for example the company PROCEQ indicator marked Profometer 3, an in-depth probe its reach to a depth of 50 mm. This method is suitable for continuous checking homogeneity of fibers per unit volume and actions at the appropriate manufacturing process. The method provides information on the global deployment of fiber. The method belongs to the non-destructive methods and to apply in practice due to easy applicability.

Non-destructive methods have the advantage of verifying and controlling the homogeneity of the dispersion and before the measurement of mechanical properties of the samples, which may be additionally carried out. It is the most common X-ray, X-ray, CT scan using a device, or a magnetic indicator reinforcement. The disadvantage of these methods is in addition to high prices and unavailability and impossibility outdoor use at the point of verification of homogeneity or near magnetic indicator only to a certain depth SFRC construction.

In Italy, efforts to evaluate the reliability of steel fiber prestressed concrete roof elements. The aim was to demonstrate that high-quality distribution of randomly oriented fibers is a key point of quality made prefabricated elements in series production. Test of prefabricated elements are drilled core sampling and were illuminated by X-rays. [3] The bottom line is the illuminated samples by X-rays. From the section drilled samples were visually counted quantity of fibers per cm^2: 0.77; 0.80; 0.58 and 0.67. These results are of course influenced by way of the addition of fibers, and towards the compaction performance of the samples. Figure represents the amount of added fiber to the desktop as well as volume.

Method CT scan allows you to view the distribution of the fibers and the layout inside the sample. [8] Made samples are scanned by computed tomography apparatus tomograph Siemens SOMATOM Sensation 64. Each scan took about 15 seconds and produced nearly 500 megabytes of data. The size of one pixel was 0.4 mm, and therefore could be scanned as a mixture of the fiber l/d = 30/0.6 mm. The advantage of this test is that it is a non-destructive method and spatial distribution can be examined from destructive to investigate the mechanical properties of the samples. The dispersion of the fibers is then converted to the quantity of fibers per cm^2. It is a marker density of detected fibers on the surface.

2.2 Destructive methods

This method does not test the mechanical control of the homogeneity of fiber concrete as the best of the sample breaks. This means that the sample is cut through a visual inspection shall verify distractions fibers or the sample is crushed and determine the global homogeneity. The disadvantage of these methods is high labor intensity and time-consuming. The benefits are lower financial requirements for implementation and ease of use on the site. The result is the quantity of fiber per unit area of overlap flat- square grid.

The first method is a violation - cut the sample multiple cuts. In order to determine the distribution of the fiber was cut surface covered with a grid of 1x1 cm mesh. They were then counted in each square of the fiber and data is recorded on the appropriate tab. Cut samples were cleaned and photographed under special lighting conditions so that the fibers reflect light, thanks to them easier recognizable and countable. [8]

Method overlap square grid has been analysed in monitoring the impact direction of sample loading, the final orientation of the fibers in the hardened UK. The results showed the possibility of direct fibers in the direction of filling the mold, and thus the effect on the mechanical properties of the structure. Examples of using the test method according to [3], in which the produced boards 1000x500x30 mm dimensions of performance in two ways. Samples were then cut into smaller and they were treated on the distribution of other horizontal and vertical cuts. Square grid can be expressed as a percentage distribution of fibers in cross-section. This research was conducted as. on the beam, which were cut in the longitudinal and transverse period. [4]

The other way of expressing the uniformity of the sample, and a crushing similarly to the in-situ method, the fibers are separated out and weighed. Followed by conversion to the unit of measure (m^3) determine the amount of added reinforcement. Again this figure serves only as information of the global homogeneity of the fiber structure, and is unable to provide information on distribution and fiber orientation. It's on the concentrations measured in fibers per unit volume. [12]

2.3 A Summary of fiber deployment

The difference between the methods is access to fiber-reinforced concrete structure, the sample and in the form of statements fiber deployment. Preferably the test directly applicable to building structures without damaging SFRC. In other trials, it is necessary to altering the structure of SFRC design in order to obtain a sample (drill core or cut test beam). If it followed for obtaining data on the deployment of fiber sample increase - ranks test to the destructive method. Of course the comparison of methods to verify the deployment of fiber pot life is the output data of sampling and availability of the measurement instruments. A comparison of these methods is summarized in the comparative table - (Table 1). Sorting test takes into account the state of SFRC samples (fresh or hardened SFRC). The output information of each method tells the global homogeneity (uniformity, or the concentration per unit volume) or the uniformity of the unit area (surface evenness).

Data on the uniformity of dispersion of the fiber have been given information on the final deployment of fibers in the hardened concrete. A first candidate is the concentration per unit volume of grinding hardened concrete example, but the position of the fibers is retained and clear. The second is the cross-sectional surface evenness of concrete as an indication of the number of detected fibers per unit area - the most common pieces/cm^2, or pieces of the square defining square grid. Uniformity in the art is therefore now comply with the mass concentration of the dosing of fibers on a set of samples to be taken and shall not be exceeded by the deviation of more than 10%. [12] This knowledge of hitherto known homogeneity led to the defined objectives, especially in the definition of uniformity and controls concentration. For the purpose of ensuring uniformity, which can therefore be specified and verified it is then possible to propose measures or equipment providing a given homogeneity.

Method (instrument)	**Type of test**	**State of fiber concrete**	**A sample of fiber reinforced concrete construction**	**Output test - data on the deployment of fiber**
Checking the amount of added fiber (DOSOMETER)	IN-SITU directly on the site	fresh	Fresh SFRC	kg/m^3, pcs/m^3
CT-SCAN (Siemens SOMATOM Sensation 64;	non-destructive	hardened	SFRC construction,	pcs/m^3, pcs/m^2

radar HILTI PS 1000 X-SCAN)			sample, bore	
X-RAY	non-destructive	hardened	SFRC construction, sample, bore	pcs/m^3, pcs/m^2
magnetic induction (PROCEQ Profometer)	non-destructive	hardened	SFRC construction, sample, bore	kg/m^3, pcs/m^3
Cutting square grid overlay	destructive	hardened	Sample, bore, cut	pcs/m^2
Crushing	destructive	hardened	Sample, bore,	kg/m^3, pcs/m^3

Tab. 1 Comparison of current methods of assessing the homogeneity of fiber

3 EVALUATION METHOD OF SUPERFICIAL HOMOGENEITY

The evaluation methodology homogeneity of the fiber cross-sections of fiber-expresses the spatial concentration of fibers. Random number of scored fibers arises from the likelihood of fiber found in cross-section of the volume. Based on fiber dimensions and calculations with respect to the volume of concrete. Stereology and morphometry expresses the issue of derivation 3D (spatial) vision using 2D (area) image projection. It means a spatial interpretation of the two-dimensional image based on probability and statistics. It can express the number of pixels per unit volume. Alternatively, spatial orientation, point density or bulk density structure. Fiber properties and their dimensions are identified. Assuming amount detected - exposing the fibers are therefore based on size and entrainment of fibers and definitions III. Stereology sentences. This sentence expresses the mean counting the intersections of random and read: every cubic meter of infinite space contains L meters of flexible fibers. If we place a space in an area of 1 square meter, then the mean number of intersections of fibers with a flat "S" calculated as (Formula 1). [1,5]

$$E(N) = \frac{Ls}{2}(-) \tag{1}$$

Where: E(N) - mean value number of times (pcs),
L - fiber length together (m),
S - surface embedded in a random (m^2).

Fiber diameter and cross-sectional area is in size fibers for stereological calculation negligible. The priority is to know the length of the fiber and the amount in the reference volume. Each cut plane should portray fibers representing each direction around an axis in 3D space as well. The same percentage of fibers demonstrated homogeneity. Fibers perpendicular to the cutting direction "axis x" recognized circle. Fibers rotated parallel to the axes "y, z" will be rendered as an ellipse. [8]

Since the fibers arranged in cross section are randomly assigned to each thread square with dimensions "and" times "and" according to the surface of a cut sample divided by the number of fiber for each direction (being the 32; 7 and 1 each). Length of the associated squares "a" is then the square root of the value of each axis. Overlap reduces occlusion sum to the total cross-sectional area. After subsequent partitioning of the area census of all the pads and the cross sectional area given a number indicating so. index uniformity. Uneven state of suspended fiber uniformity index expresses approaching zero. Index approaching the one again reveals a flatter state. An example of such expression dispersion was also prepared by AUTOCAD software 2016, and is shown in fig. 5.

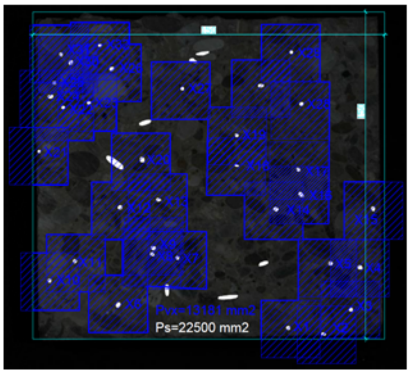

Fig. 1 Rendering index expressing the uniformity of the fiber about the axis x

Calculate the size of the boxes allocated thread is embedded in the formula 2, which is calculated for each axis in 3D. Surface boxes attached to each fiber by-axis direction is then

$$P_V = \left(\sqrt{\frac{P_S}{V}} \right)^2 \ (\mathrm{mm}^2) \qquad (2)$$

where: Ps - image area 150mm x 150mm (mm^2),
V - number of fibers software identified (pcs),
Pv - surface boxes associated thread (mm^2).

Uniformity index (degree of dispersion) is then calculated as the proportion between the total area of the frame and the amount of occlusion. This calculation is performed for all axes:

$$i_r = \frac{P_S}{\sum P_V} \ (-) \qquad (3)$$

where: i_r - index uniformity (-),
ΣP_v - amount of overlapping tabs associated fibers (mm^2).

Axis	The estimated number of fibers to slide along e(n) – vt (pcs)	The estimated number of threads per axis vt/3 (pcs)	The number of detected fibers on the axes (pcs)	Ir - index uniformity of the axes (-)
x	50	17	31	0.59
y		17	8	0.55
z		17	1	0.52

Tab. 2 The results of the test to detect the fiber cross-section

4 CONCLUSION

Studies dealing with the evaluation dispersion fibers have about the final distribution of fibers or indicate their presence around each axis in space. The research presented in this article deals with the assessment of uniformity of scattered fibers in fiber reinforced concrete structures. Fiber concrete is a composite material with the reinforcing elements ideally dispersed in the form of fibers. Each tool for assessing the evenness of fiber dispersed in a hardened fiber reinforced indicate their homogeneity. With this tool it is possible to assess the suitability of the production processes and to compare their results and impact on homogeneity. The tool creates a basis for further processing problems of homogeneity of fibers and control tool for the evaluation of manufacturing fiber reinforced concrete structures. Also it creates a basis for the development of evaluation software and more detailed statement of decomposition of forces to each priority. Use tool evaluation may consist, for example, in the evaluation of samples of fiber reinforced concrete structures.

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[10] STN EN 14889-1 Vlákna do betónu. Časť 1: Oceľové vlákna. Definície, špecifikácie a zhoda.

[11] STN EN 14845-2 Skúšobné metódy pre vlákna v betóne. Časť 2: Účinok na betón.

[12] STN EN 14721+A1 Skúšobné metódy na betón vystužený kovovými vláknami, Meranie obsahu vláken v čerstvom a zatvrdnutom betóne.